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ABSTRACT

In the mid to late 1980s, observers of education in Western Australia witnessed considerable educational change. Following an inquiry into education in Western Australia (Beazley, 1984), several major changes were made in secondary school curricula, procedures of assessment, and methods of certification. This paper explores some of the consequences of the curriculum change from compulsory year-long courses to optional short courses in the lower secondary school (grades 8 through 10; ages 13-15 years). In particular, the effects of the structural changes for gender equity in enrollment and achievement in science and mathematics are investigated and implications are drawn for the future subject and career choices of students. Although the data are from Western Australian schools, the trends observed here suggest a warning that the effects of such a major change elsewhere should be monitored carefully. (CW)

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STRUCTURAL CHANGE IN CURRICULUM: THE IMPLICATIONS FOR GENDER EQUITY IN SCIENCE AND MATHEMATICS

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STRUCTURAL CHANGE IN CURRICULUM: THE IMPLICATIONS FOR GENDER EQUITY IN SCIENCE AND MATHEMATICS

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Over the last few years observers of education in Western Australia have witnessed considerable educational change. Following an inquiry into education in Western Australia (Beazley, 1984), several major changes occurred in secondary school curricula, in procedures of assessment and method of certification. This paper explores some of the consequences of the curriculum change from compulsory year-long courses to optional short courses in lower secondary school (grades 8 through 10; ages 13 through 15 years). In particular, the effects of the structural changes for gender equity in enrolment and achievement in science and mathematics are investigated, and implications are drawn for the future subject and career choices of students. Although the data are from Western Australian schools, the trends observed here suggest a warning that the effects of such a major change elsewhere should be monitored carefully.

Curriculum Change in Lower Secondary School

Prior to 1987, the lower secondary curriculum consisted of core subjects (mathematics, science, English and social science) together with some options. Mathematics and science were studied by students for not less than 200 minutes per week, usually 240 minutes per week, or 160 hours each year. Students with different levels of ability were catered for by providing courses of different academic level. Some students could study more mathematics or science by choosing additional optional courses (such as Mathematics Enrichment, Electronics or Science Enrichment).

In 1984 the Report of the Committee of Inquiry into Education in Western Australia (Beazley, 1984) recommended that the lower secondary syllabi be organized into a modularized approach. This recommendation resulted in the introduction of the Unit Curriculum. The two major changes encompassed by the Unit Curriculum were the repackaging of the previous year-long core and option courses into 40-hour units and the great freedom of choice of units which is theoretically possible to students. The structure of the Unit Curriculum allows students to select approximately 24 40-hour units each year. Each subject area within the curriculum has units at six stages

and the more able students are expected to complete more of the higher level (stage 6) units. Assessment in all units is standards-referenced with students receiving grades of A, B, C, D or F, depending on the extent to which they have achieved the stated objectives of the unit.

At present nearly 600 units are available for study. About 25 of these units comprise the mathematics component of the curriculum, and about 35 units make up the science and technology component. In mathematics the modules are arranged into four blocks of units: the Transition block, intended to facilitate a smooth transition from primary to secondary school study in mathematics; the Mathematics For Living block, designed to address those mathematical skills and concepts which are required by students in order to be functioning members of society; the Mathematical Development block, intended as preparation for mathematical study in the final years of secondary school, and the Enrichment block, designed for students with a special interest and aptitude for mathematics. Students are able to select units from any of the blocks, although they are initially counselled on the basis of their primary school background. Most students progress from the Transition and Mathematics For Living blocks as soon as possible, while less able students are encouraged to consolidate within the Mathematics for Living block before moving on. Preferred paths and end-point units are recommended for students wishing to proceed to mathematics courses in grades 11 and 12.

In science, the transition unit provides an introduction to all aspects of science. The lower level units provide an integrated approach to science, but in later stages the units are organized so that different units address different areas of science. Students wishing to proceed with science into grades 11 and 12 are expected to study the higher level units, and particular units are considered to be prerequisites for entry into biology, chemistry and physics in grade 11.

Introduction of the Unit Curriculum

The goals of the Unit Curriculum are stated to be excellence, equity and relevance (Ministry of Education, 1988), and one of its key features is the increased flexibility students have in making their subject selections. This flexibility is intended to enable students to choose subjects which are challenging and relevant to their needs. However, this degree of choice gave science and mathematics educators serious cause for concern that the equity goal may not be achieved (see, for example, Dymond, 1987). Two questions arose. Firstly, would there be an overall reduction in the amount of science and mathematics studied in lower secondary school, particularly by females? Secondly, would females take the opportunity to opt out of science and mathematics,

particularly the physical science and higher level mathematics units, resulting in different patterns of enrolments for males and females?

Given the evidence of declining numbers of students at the upper secondary level studying chemistry, physics and the advanced stream of mathematics (Dekkers, de Laeter & Malone, 1986; Secondary Education Authority, 1986), it was not surprising that science and mathematics educators in Western Australia viewed with concern the likelihood that many, possibly even a majority, of lower secondary students would do less science and mathematics than before (Dymond, 1987; Science Teachers' Association of Western Australia, 1987). Clearly, if students take less science and mathematics at the lower secondary level, this has consequences for their subsequent choice of subjects at the upper secondary level. In turn, this will affect the number of students able to select science and engineering courses at tertiary level.

A third question about equity concerned achievement. The relative achievement of males and females in science has received considerable attention in the research literature although such differences are, in fact, quite small, an effect size of the order of 0.15 favouring males (Steinkamp & Maehr, 1983). In mathematics also, the actual difference in achievement is considerably smaller than is often assumed (Willis, 1989). The recent summary of meta-analyses conducted by Linn and Hyde (1989) measured a range of gender differences in school subjects, including mathematics and science. Their summary indicates that the differences in performance of cognitive tasks are small, declining, and are specific to cultural and situational contexts. It is clearly of interest to compare the performance of females and males in these new curriculum units. Consequently, a third issue examined in this paper is the relative performance of males and females in the Unit Curriculum.

Prior to the adoption of the Unit Curriculum, males and females studied the same science and mathematics curricula continuously in grades 8 through 10. Equal proportions of females and males studied science and mathematics in grade 10, and over the last decade, their performance has been equivalent (Parker & Offer, 1987a; 1987b). Despite their similar performance during these years of compulsory schooling, the usual sex-stereotyping of science and mathematics subject choice occurs among males and females remaining at school to grade 11 (Secondary Education Authority, 1986; 1987; 1988). The 'choice point', the time students make their subject choices to continue in the non-compulsory years of secondary school, is described by Parker (1986) as a 'critical event' which has significant consequences for students' future options.

With the introduction of the Unit Curriculum students were given choice as early as grade 8, in making their subject selections. By allowing students such choice it was possible that the 'critical event' which, in the past, occurred at the entry to grade 11, would occur earlier. There is evidence from other countries that if adolescents are offered choice between science and other subjects, females' chances of continuing in science, particularly physical science, are reduced (Whyte, 1984). If females are underrepresented in the physical science subjects and at the advanced level of mathematics in the final two years of secondary school, this clearly has implications for their choice of careers in the years beyond schooling.

In 1987, seven schools (two non-government and five government schools) became Pilot Schools for the Unit Curriculum. Under the previous curriculum structure most students studied science and mathematics for the equivalent of about four units during each of the three years of lower secondary school. Under the principles initially adopted for the Unit Curriculum, it was theoretically possible to choose no units of science or mathematics. In fact, the Pilot Schools set a minimum number of two to four units of mathematics and one to four units of science to be done each year. In 1988, all government schools and some non-government schools adopted the Unit Curriculum. In these schools the range of units in each subject and the number taken by students depends upon the selection of units available and the degree of choice and counselling offered by the school.

A major shift in curriculum structure is a very visible educational change, and a great deal of publicity has surrounded its implementation. A new Minister for Education was appointed in February, 1988, just as all government schools were implementing the Unit Curriculum in grades 8 through 10, and students, parents and teachers were voicing some misgivings. In March, a review of the curriculum was initiated and in June, in response to evidence of a reduction in the amount of mathematics selected, the Ministry of Education (1988) advised all government schools that students should study mathematics continuously in grades 8 through 10, representing a commitment of 160 hours of study per year. No such commitment was stated for science. Later, however, schools were advised to encourage students to do a minimum total of eight units in five subject areas in these grades (Ministry of Education, 1989), and one of these areas is usually science.

The gradual change in the stated requirements for the study of mathematics and science introduces an interesting perspective on the issue of choice accompanying this curriculum change. From an original position where it was possible for students to choose no science or mathematics (although this theoretical possibility was never an expectation), there is now, in government schools, an expectation of 160 hours of

study in mathematics per year for three years, equivalent in time to twelve 40-hour units. For science over these three years, there is an expectation for most students of a minimum of eight 40-hour units, or an average of 107 hours of study per year. In non-government schools, a survey by Wood and Rennie (1989) reports that there is a greater commitment to science than this minimum.

Method

The first data available to answer the questions raised by the implementation of the Unit Curriculum came from the seven Pilot Schools who adopted it in 1987. In 1988, data became available from the large majority of schools in the state. The Secondary Education Authority (SEA) is a statutory body which, as one of its roles, collects and publishes system-wide data relating to the enrolment and performance of all students in grades 9 through 12 in Western Australia. The appropriate data for the grades 9 and 10 populations for 1987 and 1988 were obtained with the cooperation of the SEA. The Pilot School population comprised approximately 1097 grade 9 students (534 males and 563 females) and 1187 grade 10 students (605 males and 582 females). The samples from the first full year of implementation (1988) represent all students who completed at least one unit of mathematics or science. For both mathematics and science the sample consists of approximately 19000 students in each subject and grade, representing 99% of each year's population. The breakdown of the exact sample sizes is reported in Table 1.

Table 1: Numbers of Grade 9 and 10 Students in Science and Mathematics in 1988

	Science			Mathematics		
	Males	Females	Total	Males	Females	Total
Year 9	10015	9782	19797	9989	9772	19761
Year 10	9741	9161	18902	9752	9331	19309

Analysis of the enrolment data involved comparisons of the percentage of the cohort of male and female students who studied each unit. To compare the achievement of males and females, an effect size (Glass,1977) was calculated based on the mean grades awarded to males and females in each unit. These data, when compared to the enrolment and performance of students in the years prior to the introduction of the Unit Curriculum, provide the basis for determining the degree to which the change in

curriculum structure has affected equity in outcomes and opportunities within the education system.

Results

Will Students Do Less Mathematics or Science?

In 1986, prior to the introduction of the Unit Curriculum, a typical Year 9 and 10 student studied 160 hours of mathematics each year although a small number studied less, and a small number studied more by taking Mathematics Enrichment. A similar situation existed for science, except that a larger number of less able students, who did not expect to continue schooling beyond grade 10, took less science. Some students also took optional courses such as Electronics and Science Enrichment. On average a student studied about 155 hours of science per year. Tables 2 and 3 provide, respectively, the mean numbers of mathematics and science units taken by males and females in Year 9 and Year 10 in 1987 (Pilot Schools) and 1988.

Table 2: Mean Number of Mathematics Units Taken by Grade 9 and 10 Students in 1987 and 1988, and Equivalent Hours of Study per Year

	1987 (Pilot Schools)				1988			
	Males	Females	Total	Hours	Males	Females	Total	Hours
Grade 9	3.46	3.55	3.51	140	3.61	3.62	3.61	144
Grade 10	3.57	3.45	3.51	140	3.45	3.43	3.44	138

Table 3: Mean Numbers of Science Units Taken by Grade 9 and 10 students in 1987 and 1988

	1987 (Pilot Schools)				1988			
	Males	Females	Total	Hours	Males	Females	Total	Hours
Grade 9	3.43	3.36	3.40	136	3.49	3.50	3.50	140
Grade 10	3.59	3.41	3.50	140	3.34	3.30	3.32	133

For each grade, the average number of units of both science and mathematics taken in the Pilot Schools represents a decrease of about 15 to 20 hours of study per year than the average in 1986. Again, for both science and mathematics, there is a small increase of about four hours per year from 1987 to 1988 for the grade 9 students. However, the Pilot Schools represent a select sample and the size of the increase must be interpreted with caution. The data for Year 10 in 1988 are not encouraging. The results indicate that under the Unit Curriculum students are doing less science and mathematics than before, even less than in the Pilot Schools.

The legitimacy of the concern that females may choose less science and mathematics than males can also be determined from Tables 2 and 3. In the Pilot Schools, females did choose less science units on average than males, but in 1988 the results are very similar. In mathematics there are differences between the numbers of units studied by the males and females in the Pilot Schools but they are not consistent. In 1988, there is no difference. These results suggest that there is no consistent trend of females taking less science and mathematics than males.

Will the Unit Choices Reflect Gender Imbalance?

Table 4 records the enrolments in mathematics units for Grades 9 and 10. The enrolment figures are recorded as percentages of the age cohort taking mathematics units, and only those units taken by at least 5% of the cohort are reported. Table 5 provides similar information for science. Units with a 5% difference in enrolment patterns are highlighted because this figure is considered to be large enough to be of practical significance.

The data from the Pilot Schools indicate some differences in gender balance for a small number of mathematics units, but these have disappeared by 1988. In fact in 1988, there is no mathematics unit where enrolment differences between males and females exceeds 5%.

In the past the first major difference in enrolment patterns for males and females has occurred at grade 11 in mathematics, and it is interesting to consider whether the pool of males and females who have sufficient prerequisites to choose the advanced mathematics course at grade 11 has changed. Prior to the introduction of the Unit Curriculum, the prerequisite for the advanced mathematics subjects in grades 11 and 12, Mathematics II and III, was considered to be a Credit or Pass at the Advanced Level of the mathematics course. In 1986, 24% of the grade 10 male cohort and 27% of the grade 10 female cohort for that year achieved a Pass or better at Advanced Level.

Despite this, in 1987, the ratio of males to females who chose to do Mathematics II and III in grade 11 was 2:1.

Table 4: Percentage Mathematics Enrolments for Grades 9 and 10 Males and Females in 1987 and 1988

Level	Unit	1987 (Pilot Schools)		1988	
		Males	Females	Males	Females
	Grade 9 Units				
21	Mathematics for Living	28.2	19.6*	16.7	15.3
22	Mathematics for Living	23.9	15.7*	18.1	16.6
23	Mathematical Development	8.9	5.2	11.3	10.6
24	Mathematical Development	4.9	4.6	14.5	13.6
31	Mathematics for Living	31.5	31.1	32.4	29.9
32	Mathematics for Living	23.7	25.6	21.9	20.6
33	Mathematical Development	44.4	50.9*	67.3	70.2
34	Mathematical Development	49.0	53.0	62.0	65.9
41	Mathematics for Living	11.5	10.1	6.6	6.5
43	Mathematical Development	41.8	45.2	53.3	56.5
44	Mathematical Development	33.5	34.7	42.5	44.3
	Grade 10 Units				
31	Mathematics for Living	22.5	18.6	16.9	15.8
32	Mathematics for Living	18.9	19.1	17.3	15.8
33	Mathematical Development	8.1	7.1	11.2	10.2
34	Mathematical Development	4.3	4.5	9.6	8.3
41	Mathematics for Living	55.5	46.0*	43.3	42.9
42	Mathematics for Living	28.8	26.7	30.5	28.2
43	Mathematical Development	10.3	7.8	14.8	13.8
44	Mathematical Development	24.8	19.4*	24.4	26.5
53	Mathematical Development	52.2	46.5*	53.3	57.2
54	Mathematical Development	50.0	44.4*	50.5	52.9
63	Mathematical Development	25.2	24.3	31.2	29.8
64	Mathematical Development	21.5	19.8	28.3	28.8

Note: Data are reported for units completed by at least 5% of students

*Sex difference in enrolments exceeds 5%

In 1988 about 30% of both males and females studied units at the Stage 6 level of the Unit Curriculum. Units at this level are considered to be prerequisites for Mathematics II and III. It appears that the pool of students at grade 10 who have the prerequisites to choose the advanced mathematics at grade 11 is approximately equal on gender grounds. It also appears that the introduction of the Unit Curriculum has not reduced the size of tnat pool.

In science the situation is different. Table 5 shows that in the Pilot Schools, there were a number of enrolment differences in grade 9, but in 1988 enrolments were similar, except that the Ecology unit was again selected by more females than males. In grade 10, three units are of particular concern. In both the Pilot Schools and the 1988 cohort, Biological Change, a Stage 6 unit, was chosen by more females than males. Also, more males than females selected the Stage 6 quantitative physics unit Forces, Motion and Energy. The stage 6 chemistry unit, Mining, Chemistry and Industry, was also taken by more males than females but two lower level chemistry units, together with an astronomy unit, were taken by approximately equal numbers of males and females. The three units relating to energy are physical science units with a society and technology bias and these also were selected by similar numbers of males and females.

Importantly, grade 10 is the year in which students make their subject choices in upper secondary school, which in turn affects their opportunities at tertiary level. Where the differences in enrolment patterns exist at the grade 10 level, they tend to be stereotypical, with females leaning towards the biological science topics and males towards the physical science units.

Prior to the introduction of the Unit Curriculum, 75% of students would have studied chemistry, biology and physics in grade 10, with an approximately equal gender balance. In 1988, only 31% of grade 10 students studied Forces, Motion and Energy, made up of 35.7% of the male cohort, but only 25.5% of the female cohort. The students studying Mining, Chemistry and Industry, comprised 37.2% of the male cohort and 31.9% of the female cohort. While 60% of grade 10 students studied Biological Change, this represented 68.9% of the female cohort compared to only 56% of the male cohort.

The enrolment pattern in Forces, Motion and Energy is of particular concern because this unit is the precursor to upper secondary physics. This subject is taken by about 20% of Grade 11 students. Whilst the percentage taking the unit in grade 10 is sufficient to maintain this level, fewer females than males will be free to choose it. In upper secondary physics the gender ratio is approximately 3:1 in favour of males at present, and it may be difficult to improve this ratio if the number of females with the

necessary background to do upper secondary physics is significantly less than the number of males. The smaller number of males taking biology units is also of concern, because many will leave school with only a rudimentary knowledge of this subject.

Table 5: Percentage Science Enrolments for Grades 9 and 10 Males and Females in 1987 and 1988

Level	Unit	1987 (Pilot Schools) Male	1987 (Pilot Schools) Female	1988 Male	1988 Female
	Grade 9 Units				
31	Me and My Environment	88.3	94.0*	88.8	90.7
32	Water: The Essential Fluid	21.1	15.7*	20.6	21.9
33	Energy in the Home	36.8	40.4	36.5	32.1
34	Ecology	36.8	47.3*	26.1	32.7*
41	Energy	60.7	63.2	75.9	77.0
42	This Chemical World	46.6	48.0	52.6	51.8
43	The World of Light and Sound	24.2	13.2*	18.1	17.6
51	Biological Field Studies	3.9	6.4	1.8	1.5
52	Our Planet and Beyond	5.7	3.7	6.9	6.6
53	Chemical Change	2.3	2.5	11.1	10.3
	Grade 10 Units				
32	Water: The Essential Fluid	14.6	10.6	4.9	4.6
34	Ecology	30.7	39.1*	16.8	19.1
41	Energy	54.2	50.7	21.2	18.0
42	This Chemical World	6.3	4.7	9.6	9.1
43	The World of Light and Sound	35.2	35.5	29.0	24.6
51	Biological Field Studies	16.9	15.1	19.7	23.6
52	Our Planet and Beyond	5.6	6.4	24.4	23.7
53	Chemical Change	57.0	59.7	51.3	53.5
61	Energy: Past, Present, Future	8.6	9.9	16.3	17.0
62	Biological Change	47.6	63.3*	56.0	68.9*
63	Mining, Chemistry and Industry	30.0	25.6	37.2	31.9*
64	Forces, Motion and Energy	32.0	18.0*	35.7	25.5*

Note: Data are reported for units completed by at least 5% students in one year.

*Sex difference in enrolment exceeds 5%

Careful guidance is needed to ensure that grade 10 students take sufficient science units to enable them to choose freely and confidently among the science courses at upper school level, and that they do not miss out on some of the major fields of study such as biology, chemistry and physics in their schooling.

Relative Performances of Males and Females

In the Unit Curriculum, students are assigned grades A, B, C, D or F. By assigning these grades 5, 4, 3, 2, 1, a mean "grade" score was calculated for males and females. These scores which can be regarded as indicators of performance are reported in Table 6 for mathematics, and in Table 7 for science. The tables also report the effect size for the difference in performance between males and females. The effect size is computed by dividing the mean difference by the within-group standard deviation (Glass, 1977). (Effect sizes were preferred to t-tests as the t-test may show statistical significance for a large sample size when, in fact, there is no practical significance.)

Table 6 clearly indicates that females have performed as well as males in mathematics in 1987 and 1988 and, in fact, the negative sign indicates that nearly all differences favour females. Effect sizes of greater than 0.2 are highlighted as they may be considered as being of practical significance, and it can be seen that although there were several large differences in the Pilot Schools, these are not evident in 1988.

The data for science in Table 7 show that the effect sizes are mostly negative, indicating that females are performing at least as well as males in most science units, and better in others. Only two of the twelve effect sizes exceeding 0.2 favour males (Chemical Change and The World of Light and Sound at the grade 9 level in the Pilot Schools), but these differences did not persist into 1988.

Table 6: Mean Grades and Effect Sizes for Grades 9 and 10 Males and Females in 1987 and 1988 (Mathematics)

Level	Unit	1987 (Pilot Schools) Males	Females	ES	1988 Males	Females	ES
	Grade 9 Units						
21	Mathematics for Living	3.21	3.18	0.02	2.75	3.00	-0.21*
22	Mathematics for Living	2.92	2.85	0.06	2.71	3.01	-0.24*
23	Mathematical Development	2.28	2.07	0.19	2.52	2.66	-0.13
24	Mathematical Development	1.81	2.19	-0.39*	2.71	2.94	-0.21*
31	Mathematics for Living	2.90	3.10	-0.17	2.87	3.02	-0.12
32	Mathematics for Living	2.90	2.91	-0.01	2.94	3.01	-0.06
33	Mathematical Development	3.27	3.26	0.00	3.17	3.27	-0.09
34	Mathematical Development	3.21	3.29	-0.06	3.12	3.27	-0.13
41	Mathematics for Living	3.34	3.5'	-0.13	3.41	3.51	-0.09
43	Mathematical Development	3.40	3.30	0.08	3.35	3.40	-0.05
44	Mathematical Development	3.48	3.51	-0.03	3.30	3.45	-0.13
	Grade 10 Units						
31	Mathematics for Living	2.86	2.83	0.02	2.78	2.95	-0.14
32	Mathematics for Living	2.72	2.95	-0.21*	2.77	2.90	-0.12
33	Mathematical Development	1.98	2.51	-0.49*	2.55	2.64	-0.08
34	Mathematical Development	2.62	2.81	-0.16	2.61	2.81	-0.18
41	Mathematics for Living	2.91	3.02	-0.09	2.93	3.10	-0.14
42	Mathematics for Living	2.78	2.66	0.09	2.88	2.95	-0.06
43	Mathematical Development	2.31	3.09	-0.69*	2.74	2.79	-0.05
44	Mathematical Development	2.80	3.23	-0.34*	2.86	3.02	-0.13
53	Mathematical Development	3.24	3.32	-0.06	3.19	3.20	-0.01
54	Mathematical Development	3.00	3.37	-0.29*	3.10	3.27	-0.14
63	Mathematical Development	3.37	3.44	-0.06	3.41	3.36	0.05
64	Mathematical Development	3.69	3.60	0.08	3.40	3.36	0.03

Note: Data are reported for units completed by at least 5% of students.

*Effect size exceeds 0.2.

Table 7: Mean Grades and Effect Sizes for Grades 9 and 10 Males and Females in 1987 and 1988 (Science).

Level	Unit Name	1987 (Pilot Schools) Males	Females	ES	1988 Males	Females	ES
	Grade 9 Units						
31	Me and My Environment	3.03	3.24	-0.18	3.09	3.35	-0.23*
32	Water: The Essential Fluid	2.48	2.76	-0.23*	2.71	2.89	-0.16
33	Energy in the Home	2.63	2.56	0.07	3.03	3.02	0.01
34	Ecology	2.86	3.14	-0.23*	3.13	3.39	-0.21*
41	Energy	3.03	3.08	-0.04	3.19	3.21	-0.02
42	This Chemical World	3.14	3.23	-0.07	3.28	3.36	-0.06
43	The World of Light and Sound	3.02	2.57	0.45*	3.37	3.36	0.01
51	Biological Field Studies	3.53	4.39	-0.83 *	3.95	3.84	0.10
52	Our Planet and Beyond	3.63	3.76	-0.12	3.75	3.73	0.02
53	Chemical Change	4.33	3.93	0.41*	3.57	3.71	-0.12
	Grade 10 Units						
32	Water: The Essential Fluid	2.39	2.57	-0.17	2.77	2.83	-0.05
34	Ecology	2.96	3.17	-0.17	2.70	3.09	-0.34*
41	Energy	2.94	2.90	0.03	2.77	2.83	-0.05
42	This Chemical World	1.92	1.96	-0.05	2.60	2.73	-0.12
43	The World of Light and Sound	2.66	2.79	-0.13	2.66	2.75	-0.08
51	Biological Field Studies	2.90	3.33	-0.41*	2.78	3.12	-0.29*
52	Our Planet and Beyond	2.82	3.16	-0.25*	2.95	2.92	0.03
53	Chemical Change	3.18	3.26	-0.07	3.15	3.21	-0.05
61	Energy: Past, Present, Future	3.13	3.14	-0.01	3.15	3.19	-0.04
62	Biological Change	3.53	3.78	-0.22*	3.22	3.42	-0.17
63	Mining, Chemistry and Industry	3.21	3.11	0.08	3.23	3.29	-0.05
64	Forces, Motion and Energy	3.49	3.38	0.10	3.38	3.48	-0.09

Note: Data are reported for units completed by at least 5% of students.

*Effect size exceeds 0.2.

Summary and Conclusions

The data presented indicate that the amount of mathematics taken by students in the 1987 Pilot Schools, and in 1988, was less than before the introduction of the Unit Curriculum. However it is likely that this has been redressed by the guidelines announced in 1988 which provided for continuous study of mathematics in grades 8 through 10 (160 hours per year). Until data are available for 1989, this cannot be demonstrated. In science, however, the data suggest that the time spent in science in lower school has been reduced by between 10% and 15% on average. Importantly, at the grade 10 level in 1988, males and females did similar amounts of mathematics and science, and there is no evidence that females are doing less of these subjects.

There seems to be little difference in choice of units in mathematics between males and females and the proportion of both sexes proceeding through to stage 6 units is similar to the proportion who previously studied at Advanced level Year 10. Again, the implementation of the 160 hours guideline inhibits choice. In science however, where students have more freedom to choose which, and how many, units they will do, differences in student choices are evident. Enrolments in higher level biology, chemistry and physics are now sex-stereotyped, and less students, overall, are receiving science instruction across a range of the science areas, particularly at the higher levels.

There is no indication that females perform less well than males in science or mathematics in any units, including those at the higher level. In fact, differences, where they exist, tend to favour females. These results support those of Parker and Offer (1987a), and imply that females can have success at least equal to males in upper secondary school science and mathematics.

In mathematics, the units tend to be considered in pathways, which lead to the various upper school options. Once students enter a pathway, there are limited possibilities to alter this. In most cases students enter these pathways based on their performance in primary school, and tend to continue in the sequence of units as long as they maintain adequate progress. In science more choice is allowed and, although pathways exist, it seems that students may be selecting their units according to their interests, or perceptions of their future. Because less units of science than mathematics are expected to be chosen, it is possible that many students will leave school with gaps in their science education. For boys these gaps tend to be in the biological science area, and for girls in the physical science area. A comprehensive survey of schools in 1989 confirms this trend (Wood & Rennie, 1989).

The patterns in enrolments, particularly in science, have implications for the Ministry of Education and for other schools following the Unit Curriculum. If it is desired that the Unit Curriculum meets its stated goal of equity, then counsellors and teachers need to ensure that students take sufficient science units in lower secondary school, and at a sufficiently high level, to enable them to choose freely in upper school. This is important not only because of the implications for students' future career options, but because of the need to ensure that students become informed and responsible decision-makers. Science teachers and curriculum developers need to consider why girls are not well represented in some units and boys in others and, if the pattern is inequitable, devise ways to redress the balance. This may require considerable change in the nature of the units themselves to ensure their attractiveness to both sexes.

The responsibility for ensuring that students study an appropriate amount of science and mathematics to pursue their eventual career choice rests squarely on school personnel. The present severe shortage of science and mathematics teachers suggests that there will be many inexperienced and less well qualified teachers in these areas than there have been in recent times. The burden of adjusting to teaching a new curriculum structure is made heavier by the need for considerable counselling and guidance to students seeking advice about unit selection. Clearly, this responsibility cannot be shirked if gender equity in enrolments and therefore future career options is to be achieved. That equity in achievement is already the norm simply underscores the importance of ensuring equity in other areas.

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